Hyperspectral Imager for the Coastal Ocean (HICO)

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LONG-TERM GOALS

The long term goal is to develop and validate the use of hyperspectral imagery for environmental characterization of the coastal ocean and land. Environmental characterization of the coastal zone includes products of value to the Navy and Marine Corps for planning and operating in these areas, including bathymetry maps [Fig. 1], water optical properties including underwater visibility, maps of bottom type, and maps of on-shore terrain and vegetation showing trafficable routes. The coastal zone is very complicated, with water of various depths, various bottom types, dissolved and suspended organic and inorganic matter, and on-shore beach, land, and vegetation.

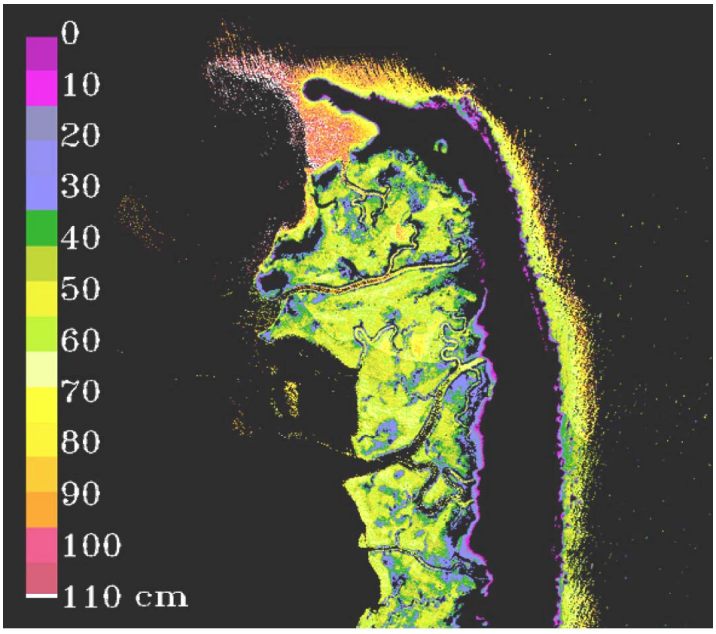

Figure 1. False-color shallow-water bathymetry map of Wreck Island, VA, derived from airborne hyperspectral imagery using a newly-developed NRL algorithm [Ref. 1]. Black areas are either deep water (left and right sides of the image) or dry land (center right in the image). Note that the large area in the center at approximately 50 cm depth is a salt marsh that is inundated at high tide.

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14. ABSTRACT
The long term goal is to develop and validate the use of hyperspectral imagery for environmental characterization of the coastal ocean and land. Environmental characterization of the coastal zone includes products of value to the Navy and Marine Corps for planning and operating in these areas, including bathymetry maps [Fig. 1], water optical properties including underwater visibility, maps of bottom type, and maps of on-shore terrain and vegetation showing trafficable routes. The coastal zone is very complicated, with water of various depths, various bottom types, dissolved and suspended organic and inorganic matter, and on-shore beach, land, and vegetation.

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Conventional remote-sensing imagery, including black and white and color imagery, in general does not contain sufficient information to discriminate among the many in-water constituents and properties, or types of vegetation. Hyperspectral imagery records a contiguous spectrum of the light received from every pixel in the scene image, and this additional spectral information is exploited to retrieve the environmental information.

OBJECTIVES

The Hyperspectral Imager for the Coastal Ocean (HICO) is the first spaceborne hyperspectral imager optimized for environmental characterization of the coastal zone. The objective of the HICO program is to exploit this global coverage to demonstrate the ability of hyperspectral imaging to produce environmental products of value to the Navy and Marine Corps in the full range of coastal types worldwide.

APPROACH

Hyperspectral imaging of the coastal zone has been developed at the Naval Research Laboratory (NRL) and the Office of Naval Research (ONR) for approximately two decades. The NRL and ONR efforts include designing and building hyperspectral imagers, developing algorithms to remove the effects of atmospheric absorption and scattering from the image data, and developing algorithms to retrieve environmental products. The programs also include aircraft deployments of imagers and extensive in-situ validation of the retrieved products.

The HICO program is a natural next step, adapting a proven imager design and existing algorithms for imaging from space. HICO has been launched to the International Space Station where it has begun imaging operations.

WORK COMPLETED

The HICO program designed, built, calibrated, and delivered the flight imager for payload integration [Fig. 2]. The program also developed and implemented the systems for: image selection and scheduling; commanding the payload; receiving the image data and ancillary data; and processing the raw imagery to level 1b including radiometric calibration and geolocation. HICO initial operations on the International Space Station began on September 24, 2009.

RESULTS

In Fiscal Year 2009, HICO was integrated into the payload module; underwent vibration and thermal-vacuum testing; underwent electrical and electronic compatibility testing to demonstrate that it would operate with the Space Station systems; was transported to the launch site at the Japanese Space Center in Tanegashima, Japan; launched to the International Space Station [Fig. 3]; and began initial operations. Valuable experience was gained in the use of Commercial-Off-The-Shelf (COTS) components; in HICO the spectrometer, camera, rotation mechanism for pointing the line of sight, and the HICO computer are all COTS, resulting in significant savings in cost and schedule. HICO provides a new capability to produce hyperspectral imagery of coastal zones worldwide using an imager optimized for coastal water and land.

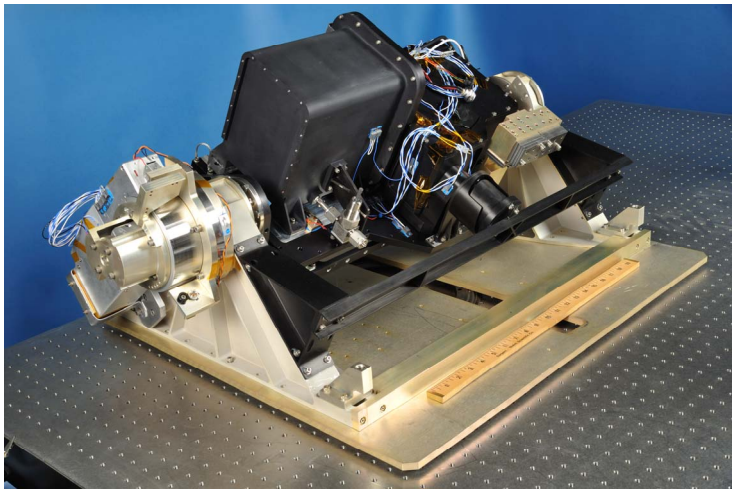

Figure 2. The flight HICO imager, prior to integration into the space payload package. The spectrometer, the camera in the hermetic container in the center, and the rotation mechanism on the left are commercial-off-the-shelf components. The camera is not designed to operate in vacuum, and therefore is inside a sealed container filled with nitrogen and incorporating a circulating fan.

Figure 3. Photograph of the payload module containing HICO being attached to the Exposed Facility of the Japanese Experiment Module, using the Japanese Remote Manipulator System. Picture courtesy of NASA

IMPACT/APPLICATIONS

HICO will demonstrate the ability of spaceborne hyperspectral imagery to produce environmental products for coastal types worldwide, and is a pathfinder for future space hyperspectral imagers and product retrieval algorithms.

RELATED PROJECTS

The Naval Research Laboratory (NRL) has begun a three-year program entitled “Realizing the Naval Scientific Return of HICO” to address issues that maximize the impact of HICO data but are beyond the scope of the HICO demonstration project. These issues include developing and implementing mission planning systems to take advantage of the full data volume that HICO can produce, understanding the consequences of the Space Station’s non-sun-synchronous orbit on the image quality, developing methods for on-orbit calibration, and the extension of NRL’s Automated Processing System (APS) to ingest and process hyperspectral imagery. APS, which is used operationally at the Naval Oceanographic Office, currently ingests multispectral satellite imagery and applies product algorithms to the multispectral data.

REFERENCES

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PUBLICATIONS

Korwan, D.R., Lucke, R.L, McGlothlin, N.R., Butcher, S.D, Wood, D.L., Bowles, J.H., Corson, M.R., Snyder, W.A., Davis, C.O., Chen, D.T., "Laboratory Characterization of the Hyperspectral Imager for the Coastal Ocean (HICO)", IEEE International Geoscience & Remote Sensing Symposium 09, Cape Town, South Africa, July 2009..

HONORS/AWARDS/PRIZES

Dr. Michael R. Corson at the Naval Research Laboratory received the NRL Award of Merit for Group Achievement, sponsored by the Naval Research Laboratory.

Dr. Robert L. Lucke at the Naval Research Laboratory received the NRL Award of Merit for Group Achievement, sponsored by the Naval Research Laboratory.

Dr. Daniel R. Korwan at the Naval Research Laboratory received the NRL Award of Merit for Group Achievement, sponsored by the Naval Research Laboratory.